Theory of Mind and Pragmatic Understanding Following Right Hemisphere Damage

MICHAEL SIEGAL, JANET CARRINGTON, AND MICHAEL RADEL

University of Queensland, Brisbane, Australia

It has been maintained that 3-year-olds' difficulties in correctly predicting the undesired outcome of false beliefs reflects difficulties in interpreting the implications of conversations rather than a conceptual limitation in their theory of mind. As the right hemisphere has been seen to be responsible for the interpretation of the pragmatic aspects of communication, right-hemisphere-damaged (RHD) and left-hemisphere-damaged (LHD) adult patients in our study were compared on their ability to correctly draw inferences in false belief tasks. The RHD but not the LHD patients were found to have difficulties similar to those of young children in understanding the conversational implications of test questions. Most reported that a central story character would look for a pet in the place where it was really located instead of where the character believed it was located. However, when then asked in a control question where the pet really was, the RHD patients often switched their answer to the test question and referred to the believed location. Removal of the need to infer the questioner's meaning enabled both RHD and LHD subjects to make correct false belief predictions. The results are discussed in terms of the effects of brain damage on spatial memory and the pragmatic demands of theory of mind tasks.

In recent years, a very large number of studies have been carried out on the development of children’s theory of mind (for reviews, see Astington, Harris, & Olson, 1988; Butterworth, Harris, Leslie, & Wellman, 1991; Perner, 1991; Premack & Dasser, 1991; Wellman, 1990). However, whether or not young children can be said to have insight into others’ mental states remains controversial (Flavell, Mumme, Green, & Flavell, 1992; Siegal & Peterson, 1994; Sullivan and Winner, 1993).

Many researchers have concluded that there is a form of ‘‘conceptual limitation’’ in children’s ability to understand the critical relation between beliefs and behavior. For example, in a notable series of studies, Wellman and Bartsch (1988) have found that 3-year-olds and young 4-year-olds do poorly
on stories that require an understanding of ‘explicit false beliefs.’ In these tasks, a story character’s desire to find an object is explicitly mentioned, the object is said to be really in one location, and the character is said to believe that the object is in another (wrong) location (e.g., ‘‘Jane wants to find her kitten. Jane’s kitten is really in the playroom. Jane thinks the kitten is in the kitchen. Where will Jane look for her kitten?’’ Correct answer, kitchen; 3-year-olds’ common answer, playroom). In a fashion that is reminiscent of Piaget’s (1970) emphasis on egocentrism, Wellman and Bartsch have proposed that 3-year-olds do not fully appreciate that desires can be unfulfilled owing to the location of identities in the external world. Though they can often determine how behavior follows from beliefs, they weight desires over beliefs when these are in conflict in false belief tasks. In support of this explanation, Wellman and Woolley (1990) have reported that 2-year-olds and young 3-year-olds succeed on tasks that involve predicting behavior on the basis of desires while failing false belief tasks.

Sodian, Taylor, Harris, and Perner (1991) have maintained that young children’s poor performance on such false belief tasks cannot be attributed to pragmatic difficulties in understanding the purpose and implications of questions. Rather, they have claimed that 3-year-olds are constrained by a conceptual deficit that precludes the ability to understand how actions can lead to deceptive beliefs and outcomes. Together with Karmiloff-Smith (1992, pp. 169–170), they speculate that this conceptual limitation may have a neuropsychological underpinning. Indeed, Thatcher (1992, p. 44) comments that children’s successful performance on theory of mind research at 4 years of age is a ‘‘milestone’’ in cognitive development which, he points out, concurs with a surge of growth in the right frontal lobe.

Yet for subjects to succeed on explicit false belief tasks, they must understand that the scientific purpose is to test whether they can detect how others’ thoughts may be initially mistaken. It is assumed in these tasks that children follow the implications of the language used by the experimenter and infer that false belief test questions such as, ‘‘Where will a person (with the false belief) look for the object?’’ mean ‘‘Where will the person look first?’’ If this assumption is unwarranted, children who can predict the consequences of holding false beliefs may not reveal their knowledge because they do not share the experimenter’s purpose in questioning rather than because they weight desires over beliefs. Instead the purpose may appear to be something more familiar and straightforward: to test whether children can predict the behavior of others in achieving a goal. The question, ‘‘Where will Jane look for her kitten?’’ may simply be interpreted as ‘‘Where will Jane have to look (or go to look) for her kitten in order to find it?’’ rather than ‘‘Where will Jane look first for her kitten?’’ which is the implication intended by the experimenter who has assumed that the child shares the purpose of the task. Support for this position comes from studies using tasks in which children are not required to follow the implications of conversations. On these modi-
fied false belief prediction tasks in which children are asked questions such as ‘Where will Jane look first for her kitten?’ even 3-year-olds can correctly predict the consequences of holding a false belief (Lewis & Osborne, 1990; Siegal, 1991; Siegal & Beattie, 1991; Siegal & Peterson, 1994). Such results suggest that children’s difficulty can be considered in terms of pragmatic factors rather than mainly consigned to a conceptual limitation in which they cannot conceptualize how another’s false belief can lead to an undesired outcome—even when the need to follow conversational implications is eliminated.

In this connection, it is widely accepted that there is a neuropsychological basis to pragmatic development. Considerable research on adult subjects has shown that the right hemisphere predominates in influencing the interpretation of conversation (Kaplan, Brownell, Jacobs, & Gardner, 1990; Molloy, Brownell, & Gardner, 1990; Kasher, 1991; Zaidel, 1985) and in distinguishing internal emotional states (Cicone, Wapner, & Gardner, 1980). For example, patients with right hemisphere damage have difficulty in interpreting indirect requests and commands and rely on the literal meanings of conversations rather than pragmatic cues that involve deriving meaning from contextual information (Foldi, 1987; Weylman, Brownell, Roman, & Gardner, 1989). They also often do not recognize the relevance of the theme of a story in understanding narratives (Schneiderman, Murasugi, & Saddy, 1992). Therefore a neuropsychological basis to children’s responses on theory of mind measures that require a recognition of the purpose and relevance of the task may involve pragmatic understanding rather than being solely conceptual in nature.

The purpose of this study was to compare the performance of right-hemisphere brain-damaged (RHD) and left-hemisphere brain-damaged (LHD) patients on theory of mind tasks. Our hypothesis was that, compared to LHD patients, RHD patients would answer false belief questions that require listeners to follow the implications of conversations more incorrectly and that their answers would resemble those of 3-year-olds in previous research. By contrast, we expected that both RHD and LHD patients would be proficient at answering questions that do not require listeners to share the implications of conversations. This pattern of findings would support the position that difficulties in pragmatic understanding rather than a conceptual deficit accounts for the unsuccessful performance of both young children and adults on many theory of mind tasks.

METHOD

Subjects. These were 17 RHD and 11 LHD stroke patients who had suffered unilateral cortical brain damage as the result of a single cerebrovascular accident. The RHD patients consisted of 7 males and 10 females ages 41 to 83 years (M = 69.2 years, SD = 10.9). RHD and LHD subjects were matched as closely as possible in regard to age, lesion site, years of education, and length of time since onset of the stroke. The LHD patients consisted of 8 males
and 3 females ages 45 to 80 years ($M = 70.3$ years, $SD = 9.7$). The mean number of years of education for RHD patients was 8.6 (range = 6 to 15 years) and the mean for LHD patients was 8.2 (range = 6 to 13 years). The period of time which had elapsed between onset of the stroke and testing ranged from 1 to 24 months ($M = 6.2$, $SD = 6.9$) for RHD subjects and from 1 to 68 months ($M = 16.4$, $SD = 19.3$) for LHD subjects. Based on patient reports, subjects were right handed before the onset of the stroke.

The patients were selected from medical records according the criteria used by Kaplan et al. (1990). Lesion site was determined by neurological examination and computerized transaxial tomography (CT scan). Information on the subjects in the two conditions of the study is given in Table 1.

Only subjects in whom a single site of damage could be identified and who had no history of a severe cognitive impairment were included in the study. Patients with a history of psychiatric disturbance or who had receptive aphasia or severe expressive aphasia that precluded coherent speech were excluded.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Education (years)</th>
<th>Time postonset (months)</th>
<th>Lesion site</th>
</tr>
</thead>
<tbody>
<tr>
<td>FB-I + TB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RHD1</td>
<td>73</td>
<td>10</td>
<td>5</td>
<td>Parietal</td>
</tr>
<tr>
<td>RHD2</td>
<td>73</td>
<td>7</td>
<td>3</td>
<td>Fronto-parietal</td>
</tr>
<tr>
<td>RHD3</td>
<td>69</td>
<td>10</td>
<td>2</td>
<td>Parietal</td>
</tr>
<tr>
<td>RHD4</td>
<td>53</td>
<td>8</td>
<td>1</td>
<td>Temporal</td>
</tr>
<tr>
<td>RHD5</td>
<td>56</td>
<td>8</td>
<td>2</td>
<td>Parietal</td>
</tr>
<tr>
<td>RHD6</td>
<td>79</td>
<td>6</td>
<td>6</td>
<td>Parietal</td>
</tr>
<tr>
<td>RHD7</td>
<td>41</td>
<td>15</td>
<td>12</td>
<td>Fronto-parietal</td>
</tr>
<tr>
<td>RHD8</td>
<td>65</td>
<td>7</td>
<td>6</td>
<td>Parietal</td>
</tr>
<tr>
<td>RHD9</td>
<td>74</td>
<td>9</td>
<td>5</td>
<td>Fronto-parietal</td>
</tr>
<tr>
<td>RHD10</td>
<td>76</td>
<td>7</td>
<td>6</td>
<td>Parietal</td>
</tr>
<tr>
<td>RHD11</td>
<td>60</td>
<td>10</td>
<td>24</td>
<td>Temporo-parietal</td>
</tr>
<tr>
<td>LHD1</td>
<td>70</td>
<td>7</td>
<td>28</td>
<td>Temporo-parietal</td>
</tr>
<tr>
<td>LHD2</td>
<td>72</td>
<td>6</td>
<td>18</td>
<td>Parietal</td>
</tr>
<tr>
<td>LHD3</td>
<td>73</td>
<td>7</td>
<td>6</td>
<td>Fronto-parietal</td>
</tr>
<tr>
<td>LHD4</td>
<td>61</td>
<td>8</td>
<td>10</td>
<td>Fronto-temporal</td>
</tr>
<tr>
<td>LHD5</td>
<td>80</td>
<td>13</td>
<td>68</td>
<td>Temporo-parietal</td>
</tr>
<tr>
<td>LHD6</td>
<td>45</td>
<td>10</td>
<td>11</td>
<td>Fronto-parietal</td>
</tr>
<tr>
<td>FBLF + TBLF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RHD12</td>
<td>75</td>
<td>11</td>
<td>3</td>
<td>Temporal</td>
</tr>
<tr>
<td>RHD13</td>
<td>74</td>
<td>8</td>
<td>22</td>
<td>Fronto-parietal</td>
</tr>
<tr>
<td>RHD14</td>
<td>75</td>
<td>8</td>
<td>2</td>
<td>Fronto-temporal</td>
</tr>
<tr>
<td>RHD15</td>
<td>71</td>
<td>9</td>
<td>1</td>
<td>Parietal</td>
</tr>
<tr>
<td>RHD16</td>
<td>79</td>
<td>7</td>
<td>4</td>
<td>Temporo-parietal</td>
</tr>
<tr>
<td>RHD17</td>
<td>83</td>
<td>6</td>
<td>2</td>
<td>Temporo-parietal</td>
</tr>
<tr>
<td>LHD7</td>
<td>76</td>
<td>6</td>
<td>1</td>
<td>Fronto-parietal</td>
</tr>
<tr>
<td>LHD8</td>
<td>72</td>
<td>10</td>
<td>2</td>
<td>Temporal</td>
</tr>
<tr>
<td>LHD9</td>
<td>78</td>
<td>7</td>
<td>4</td>
<td>Parietal</td>
</tr>
<tr>
<td>LHD10</td>
<td>75</td>
<td>9</td>
<td>24</td>
<td>Temporo-parietal</td>
</tr>
<tr>
<td>LHD11</td>
<td>72</td>
<td>7</td>
<td>13</td>
<td>Temporo-parietal</td>
</tr>
</tbody>
</table>
Procedure. Each patient received an information sheet that outlined the purpose and the procedure of the study and then signed a participation consent form.

The patients were randomly assigned and tested individually in one of two conditions. In one of these conditions (FB-I + TB), 11 RHD and 6 LHD patients were given a false belief (FB-I) task that required them to follow the implication that the question refers to where the story character will look first for a pet together with a true belief (TB) task in which the character possessed a true belief that related to the pet’s actual location. In the other condition (FBLF + TBLF), 6 RHD and 5 LHD patients were given a false belief task that did not require them to follow the implication (FBLF) together with a corresponding true belief task (TBLF). For both tasks in either condition, the patients were initially asked a test question and then a control question aimed at determining whether they could remember the other location of the object.

A female experimenter tested each patient on two stories following the procedure described by Siegal and Beattie (1991). Only these stories were used to provide a direct comparison with performance shown in previous research and to avoid the effects of fatigue and presentation order on responses which can influence both children’s and patients’ responses (Huber & Gleber, 1982; Siegal, 1991).

The experimenter read each story and then asked a test question followed by a control question. For those in the FB-I + TB condition, the FB-I story was “Sam wants to find his puppy. Sam’s puppy is really in the kitchen. Sam thinks his puppy is in the bathroom. (FB-I test question:) Where will Sam look for his puppy? (FB-I control question:) Where is it really?” The location of the pets in the stories was counterbalanced across subjects so that, for half the patients, Sam was said to believe that his puppy was in the bathroom (real location: kitchen); for the other half, the real and believed locations were reversed.

For the TB task, the situation was “Jane wants to find her kitten. The kitten lives in two rooms: the garage and the lounge. Jane thinks her kitten is in the garage and now it really is in the garage. (TB test question:) Where will Jane look for her kitten? (TB control question:) Where is the other room that the kitten lives in?” (The notion of the other room was introduced to provide a relevant context for asking subjects about where Jane will look.)

The procedure for the FBLF task was identical to that of the FB-I task except that the patients were asked the test question, “Where will Sam look first for his puppy? followed by the control question, “Where is the other place that the puppy lives?” The TBLF task was the same as the TB task except that the patients were asked, “Where will Jane look first for her kitten?

Within each group, the order of the stories was counterbalanced as was the order of the premises concerning beliefs and reality.

RESULTS

The responses of the groups are shown in Table 2. These indicated that nearly all the RHD and LHD patients answered correctly on the FBLF and TBLF test and control questions correctly. In the FB-I + TB condition, nearly all the LHD group scored correctly as well on both questions for the FB-I and TB tasks.

By contrast, as hypothesized, only 3 of the 11 RHD patients were correct on the FB-I test question. Of the 8 patients who answered this question incorrectly, only one was also incorrect on the TB test question ($p = .035$, one-tailed binomial test). The performance of the RHD patients on the FB-I test question was significantly poorer than LHD patients on the FB-I test question and than RHD patients on the FBLF test question (in both instances, $p = .04$, one-tailed Fisher test).
Unexpectedly, seven of the eight RHD patients and the only LHD patient who did not succeed on the FB-I test question also answered the FB-I control question incorrectly. This result stands in contrast to the performance of the 3-year-olds who were correct on the control question in the research of Wellman and Bartsch (1988) and Siegal and Beattie (1991).

An examination of effects related to the presentation orders of the stories and alternatives did not reveal any significant differences in the pattern of responses.

Three separate 2 (condition) by 2 (groups) ANOVAs were carried out to determine if the groups differed significantly on the variables of age, years of education received, or the time elapsed since onset of the stroke. The analyses revealed no significant interactions and only one significant main effect. Patients in the FB-I + TB condition were significantly younger than those in the FBLF + TBLF condition, $F(1, 24) = 5.92, p < .03$. Despite the comparative youthfulness of the subjects in the FB-I + TB condition, they did not outperform those in the FBLF + TBLF condition.

DISCUSSION

Our study provides an initial examination of brain-damaged subjects’ performance on theory of mind tasks. The results pertain only to the explicit false belief prediction tasks used in the work of Wellman and Bartsch (1988) and Siegal and Beattie (1991) and indicate that a conceptual limitation is not the sole determinant of responses. They do not directly bear on the different false belief tasks that have been used in other research to support explanations for poor performance that are consistent with a form of conceptual deficit (e.g., Gopnik & Slaughter, 1991; Moses & Flavell, 1990; Perner, Lee-kam, & Wimmer, 1987). Additional investigation is required to determine the extent to which pragmatic factors provide a general account of theory of mind responses and to examine the relation between pragmatic under-
standing and knowledge of mental states (see Siegal & Peterson, 1994, for a discussion of these issues).

Acknowledging this limitation, our hypothesis that RHD patients would have difficulties in understanding the conversational implications of false belief prediction tasks was supported, as was the hypothesis that removal of the need to follow the implications would enable RHD subjects to answer correctly. The tasks that were presented to the subjects are likely to be correctly answered by children ages 4–5 years (Siegal & Beattie, 1991; Wellman & Bartsch, 1988) and, as shown in the present study, by LHD adults. Therefore, the RHD patients’ difficulties in making false belief predictions may be considered as due to pragmatic language deficits.

The finding that RHD subjects had difficulty in interpreting the pragmatic aspects of language when they were required to draw an inference about the experimenter’s meaning in a false belief prediction task is consistent with the results of a number of other studies (e.g., Brownell, Potter, Bihlre, & Gardner, 1986; Bryan, 1988; Foldi, 1987; Molloy et al., 1990; Moya, Benowitz, Levine, & Finklestein, 1986; Van Lancker & Kempler, 1987; Weylman et al., 1989). These studies also found that RHD subjects had difficulty in appreciating the implications of passages and in drawing correct inferences from the available information. As the stimuli used in this study were simpler than many of those used in earlier studies, the deficits which RHD subjects have in understanding the conversational implications of questions appear to exist even at a basic level. Their misinterpretations are of a very subtle nature and can interfere with quite simple communication.

The RHD patients’ responses on the test questions in our study are consistent with the position that 3-year-olds’ deficits in false belief prediction often result from difficulties with pragmatic language interpretation and that the success of older children can be attributed to their pragmatic language development (Siegal, 1991; Siegal & Peterson, 1994). Although it may be an anatomical coincidence, it is worth noting that this development concurs with the right hemisphere growth spurt sequences at around 4 years of age that have been reported by Thatcher (1992).

However, there is a problem with an explanation that favors pragmatic influences on performance. In contrast to earlier research with children, patients who were incorrect on the FB-I test question were also often incorrect on the FB-I control question. This difference may be attributed to methodological differences between studies. During the story presentation in the Siegal and Beattie (1991) study in which the children were able to answer the control question correctly by stating that the real location of the pets, the experimenter referred to miniature figures and to locations inside a doll house. In our study, the patients did not receive this visual presentation. Thus the two locations of the pet—where it was “really” and where it was believed to be—may have been less salient and hence less easily remembered.

In this regard, McDonald and Wales (1986) have suggested that the right
hemisphere plays a particular role in processing verbal material which requires visuospatial imagery and that RHD individuals may experience difficulty in accurately retrieving spatial information. Moya et al. (1986) have reported that the RHD subjects in their study were impaired on a number of tasks involving visuospatial abilities. They also found that the recall of the details of verbal passages was moderately correlated with visuospatial ability. Although the tasks used in the present study were simpler than those used by Moya et al., it is likely that some visuospatial ability was required to respond correctly in this study as each task required subjects to deal with two locations and to predict where the protagonist would look. Recently, Jonides, Smith, Koepppe, Awh, Minoshima, and Mintun (1993) have argued that one component of working memory, which is essential for language comprehension, is a set of buffers which temporarily store information in either visuospatial or phonological form. Using positron emission tomography scans to measure regional cerebral blood flow in subjects who were engaged in perception and memory tasks, they found that significantly increased activation in areas of right hemisphere accompany the performance of tasks involving spatial working memory processes. Therefore, it is possible that the incorrect responses of the RHD subjects on the FB-I task were related to a working memory deficit caused by visuospatial difficulties rather than to pragmatic language difficulties. Yet the fact that the RHD subjects on the FBLF task did not experience the same problems and answered the test and control questions correctly detracts from this explanation. Moreover, the difficulties of RHD patients on language comprehension tasks are not merely restricted to those requiring a representation of spatial information (Delis, Wapner, Gardner, & Moses, 1983).

An alternative and, in our view, more viable explanation for the patients’ difficulties resides once more in the domain of pragmatic language comprehension. The RHD patients may have interpreted the control question “Where is it really?” to mean that they should name the location other than the one that they had given in answer to the test question. The patients may have felt that in order to be consistent with their response to the test question, they should indicate that the pet was really in the other location. The wording of the control question may also have indicated to adults that the one location could not be the correct answer to both the test question and the control question.

The stories and questions used by Siegal and Beattie (1991) was retained in our study in order to provide a comparison between children’s responses and those of brain-damaged adults. As the majority of subjects in this study were elderly people who may lose interest or tire easily during testing, the simplicity of the tasks had the added advantage of not being overly taxing for the subjects. Although the wording of the stories, particularly the reference to “kitten” and “puppy,” may have led adults to regard the tasks as trivial or irrelevant and story interest has been previously shown to influence RHD
subjects’ comprehension (Rehak, Kaplan, Weylman, Kelly, Brownell, & Gardner, 1992), all the patients in our study were cooperative and appeared to be motivated when responding to the questions.

Nevertheless, the simplicity of the tasks, while appropriate for children, may have confused some of the adult subjects because they expected the questions to be more difficult. Individuals with RHD have been found to have some difficulties with the emotional content of communications (Bryan, 1988; Cicone et al., 1980; Gardner, Brownell, Wapner, & Michelow, 1983; Molloy et al., 1990). For example, Bryan points out that emotional information is often not directly conveyed but is dependent on inferences which may partly account for RHD patients’ difficulties with emotional content. Problems with affect may have prompted some RHD subjects to answer incorrectly because they suspected that such simple tasks would contain trick questions.

Future research could make use of adult versions of the tasks in which, for example, a story character would desire to find his or her keys rather than a pet. In addition, in a modified control question, visual cues could be introduced to facilitate memory in which subjects would be asked to report both the believed and actual location of the desired object. Investigations could also involve studies in areas related to the understanding of false beliefs such as deception (Sodian et al., 1991) and the distinction between lies and mistakes (Siegal and Peterson, in press) that are also liable to difficulties in pragmatic language interpretation. To this end, a more comprehensive picture of brain-damaged subjects’ theory of mind would contribute toward formulating methods of effective communication and rehabilitation.

REFERENCES


